MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019/2020

ETN3046 – ANALOG AND DIGITAL COMMUNICATIONS

(All Section / Groups)

18 OCTOBER 2019
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 7 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider a periodic signal $v(t)$ shown in Figure Q1.1.

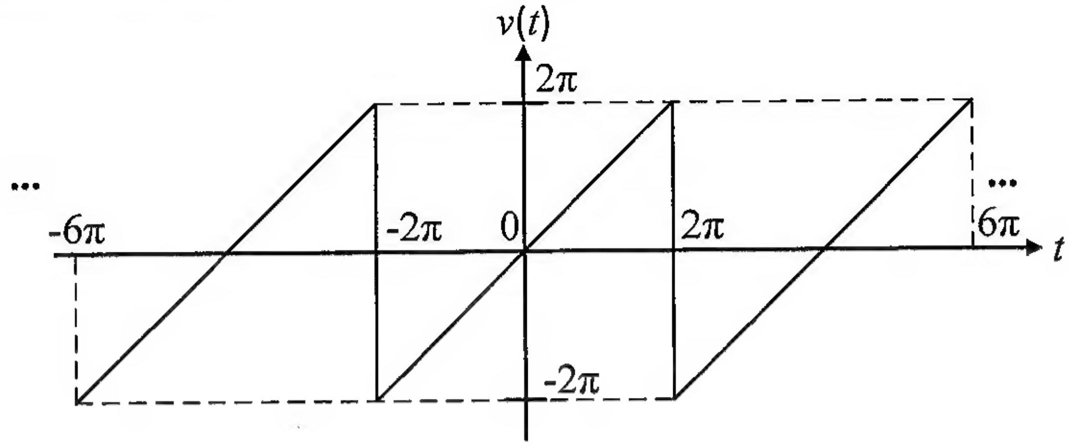

Figure Q1.1: Periodic signal $v(t)$.

(i) Compute the mean value of $v(t)$.

[1.5 marks]

(ii) Determine the trigonometric Fourier series of $v(t)$.

[9 marks]

(iii) Calculate the phase of $v(t)$ at the 3rd harmonic.

[1.5 marks]

(iv) Sketch the double-sided magnitude spectrum of $v(t)$ for n = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $v(t)$.

[3 marks]

(b) Consider a signal $s(t) = 9e^{-2t}u(t)$, where $u(t)$ denotes unit step function.

(i) Determine the Fourier transform of $s(t)$.

[3.5 marks]

(ii) Compute the average normalized energy of $s(t)$.

[3.5 marks]

(iii) By applying the properties of the Fourier transform, find the Fourier transform of $z(t) = 18e^{2t}u(-t)$.

[3 marks]

Continued ....

Question 2

(a) A message signal $m(t) = A_m \cos(2\pi f_m t)$ modulates a carrier signal $c(t) = A_c \cos(2\pi f_c t)$ using a double sideband large carrier (DSB-LC) modulation scheme. The total transmission power of the DSB-LC modulated signal is 12 kW and the power contained in the lower sideband of the modulated signal is 1.115 kW. Assume that f_m = 4.2 kHz and f_c = 900 kHz. Calculate the following:

(i) Carrier power. [2 marks]

(ii) Modulation index. [3 marks]

(iii) Power efficiency of this DSB-LC transmission scheme. [2 marks]

(iv) Bandwidth of the DSB-LC modulated signal. [1 mark]

(b) Discuss the differences between single sideband (SSB) modulation and vestigial sideband (VSB) modulation in terms of the bandwidth and the spectrum of the modulated signal. [4 mark]

(c) Consider a frequency modulated signal that is expressed as follows:

$$w(t) = 2.9\cos\left\{(2\pi)\left(1.75\times10^{6}t\right) + 2\sin\left[9.5\pi\times10^{3}t\right]\right\}$$

Assume that $w(t)$ is supplied to a load of 1 ohm.

(i) Is $w(t)$ narrowband frequency modulated or wideband frequency modulated? Justify your answer. [2 marks]

(ii) Determine the frequency of the message signal. [1 mark]

(iii) Calculate the frequency deviation. [2 marks]

(iv) Calculate the bandwidth of $w(t)$ based on the Carson's rule. [2 marks]

(v) Compute the average power of $w(t)$. [1 mark]

(vi) The frequency modulated signal $w(t)$ is passed through an ideal bandpass filter (BPF), which has a centre frequency of 1.75 MHz, bandwidth of 40 kHz, and a gain of unity. Determine the number of sidebands that will pass through the BPF without being attenuated. [5 marks]

Continued ....

Question 3

(a) For the simplified block diagram of a communication system shown in Figure Q3.1, answer the following questions

(i) Identify the blocks that constitute the ***physical layer*** (or simply denoted as the PHY) of a communication system.

[2 marks]

(ii) For a digital communication system, draw and briefly explain the sub-components of the ***transmitter*** block.

[6 marks]

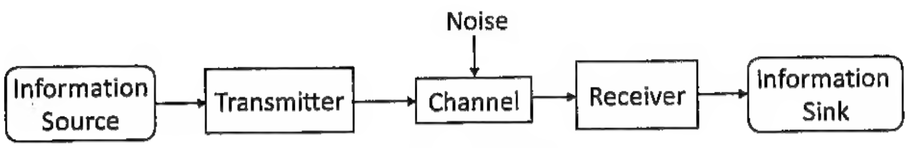

Figure Q3.1

(b) (i) An analogue signal is to be sampled before being converted into a digital signal. An anti-aliasing filter is used before sampling the analogue signal. Describe the rationale for using the anti-aliasing filter.

[3 marks]

(ii) Figure Q3.2 shows the spectrum of a sampled signal where B and f_s denote the maximum bandwidth of the original analog signal and the sampling frequency, respectively. Explain how the original ***analogue signal*** can be retrieved from the sampled signal, and sketch the ***spectrum*** of the retrieved analogue signal.

[4 marks]

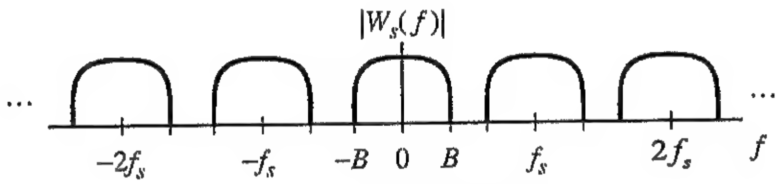

Figure Q3.2

(c) A digital modem uses quadrature phase-shift keying (QPSK) modulation to transmit data at a rate of 30 Mbit/s over a channel with a bandwidth of 24 MHz. If the signal is equalised to have an equivalent raised cosine filter characteristic, determine the rolloff factor r required. With the rolloff factor r you obtained, determine the percentage of bandwidth saving if 64-QAM modulation is used for data transmission.

[4 marks]

(d) A modulated signal with a bandwidth of 2 MHz is transmitted over a wireless channel with a coherence bandwidth of 0.5 MHz. With the aid of appropriate time and frequency-domian diagrams, explain whether intersymbol interference (ISI) exists on the received signal. If ISI exists, suggest a solution to mitigate it at the receiver.

[6 marks]

Continued ……

Question 4

(a) Figure Q4.1 shows a modulated waveform obtained from a digital modulation scheme.

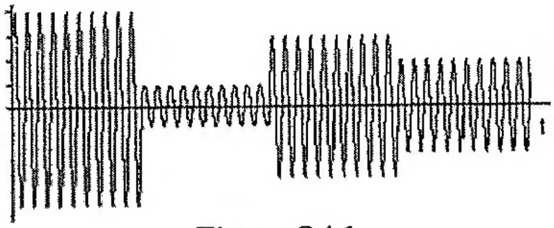

Figure Q4.1

(i) Name and briefly describe this type of modulation scheme.

[3 marks]

(ii) State the number of data bits carried by each symbol.

[1 mark]

(iii) Choose another digital modulation scheme in order to transmit data at twice the bit rate without increasing the bandwidth, and sketch the modulated waveform using the same symbol rate in Figure Q4.1 for your chosen modulation scheme.

[4 marks]

(b) A discrete memoryless source generates seven messages $\{x_1, x_2, x_3, x_4, x_5, x_6, x_7\}$ with respective probabilities of occurrence $\{0.49, p_2, 0.12, 0.04, 0.04, 0.03, 0.02\}$.

(i) Determine p_2, i.e., the probability of occurrence for symbol x_2.

[1 mark]

(ii) Obtain the Huffman code for these messages by moving a combined symbol as high as possible.

[7 marks]

(iii) Calculate the average codeword length of the Huffman code.

[1 mark]

(c) A (7,4) systematic Hamming code has the following parity-check matrix **H**.

$$\mathbf{H} = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

(i) Obtain the generator matrix **G**.

[2 marks]

(ii) Given that codeword $\{1001110\}$ is received, calculate the syndrome and investigate if an error has occurred. If it has, perform error correction using syndrome decoding.

[6 marks]

Continued ......

APPENDIX

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Useful Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}[\cos(A-B)-\cos(A+B)]$$

$$\cos A \cos B = \frac{1}{2}[\cos(A+B)+\cos(A-B)]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta}-e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta}+e^{-j\theta}\right]$$

Continued ....

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper